



# CONGRESSIONAL TESTIMONY



TESTIMONY OF

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I am Dr. J. Donald Millar, Director of the National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control, in the Public Health Service of the Department of Health and Human Services. I appreciate this opportunity to report to you on the activities of NIOSH in the area of indoor air quality.

Our experience with evaluating and understanding indoor air quality problems is based on the research and technical assistance that we have conducted under the mandates of the Occupational Safety and Health Act (OSH Act). Our knowledge, therefore, relates to the health effects on workers in nonresidential and nonindustrial workplaces, including Federal buildings, schools, and other public buildings, commercial buildings and portions of commercial vehicles occupied by workers. In addition to dealing with air quality, this knowledge base includes data on ergonomic and psychosocial problems that also affect workers.

More specifically, most of our knowledge on indoor air quality problems has been generated on the "technical assistance side" of our responsibilities under the OSH Act. This assistance is conducted under Section 20(a)(6) of the OSH Act through our Health Hazard Evaluation (HHE) Program, where we respond to requests from employers, employees, employee representatives, State and local agencies and other Federal agencies. Presented below is a brief narrative of how the HHE Program is utilized for indoor air quality investigations, and what we have learned from these investigations in regard to the extent of the problem. Additional details are shown in Enclosure I.

In the 1970's, following the Arab oil embargo, energy conservation programs were encouraged throughout the United States. The operations of buildings changed in an effort to conserve fossil fuels and operating costs. Ventilation rates were reduced and buildings were sealed to prevent infiltration of untempered outside air (hot, humid air in the summer months and cold, dry air in the winter months). At the same time, there was a revolution occurring in buildings throughout the country. Computers forced a change in office procedures and productivity leading to ergonomic and organizational stress problems. Some of these new office technologies brought with them chemical and physical hazards.

We saw the effect of the conservation measures, as well as problems associated with the shifts in office automation (e.g. video display terminals, vision problems), and concern about asbestos and radiation, through increases in requests for assistance in the HHE Program. Of the 1,200 Health Hazard Evaluations between 1971 and 1978, NIOSH investigated six indoor air quality problems or 0.5% of the total. From 1978 to 1980, the percentage of HHE's have averaged 12% of all health hazard evaluations. More recently, on an annual basis, this has increased to approximately 20%. For example, in FY 1988 through the present, NIOSH's toll free information number has received an average of approximately 60 inquiries and requests for assistance per month on indoor air quality problems. In 1988, in addition to providing background information and a copy of NIOSH's indoor air quality guidance document (Enclosure I) to most of these callers, NIOSH researchers conducted 45 field investigations.

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Table 1 presents the number of HHE investigations by building type since the Program was initiated in 1971. (These totals do not include complaints arising from asbestos contamination--the number of which also is significant--or complaints regarding radon.)

TABLE 1

NIOSH Indoor Air Quality  
Investigations by Building Type  
(through December 1988)

| Building Type                      | Number<br>Completed | Percent<br>of Total |
|------------------------------------|---------------------|---------------------|
| Government and<br>Business Offices | 426                 | 80                  |
| Schools and Colleges               | 68                  | 13                  |
| Health Care Facilities             | <u>35</u>           | <u>7</u>            |
| Total:                             | 529                 | 100                 |

We have not seen a decrease in indoor air problems and we are concerned that as the U.S. moves more and more to a service and information economy, with increases in office workers, the problems will increase.

Indoor air quality problems may arise from a variety of sources including human metabolic activity, smoking, structural components of the building and contents, biological contamination, office and mechanical equipment, and outside air pollutants that enter the building. Commonly, the symptoms and health complaints reported by workers are diverse and not specific enough to readily identify the causative agent (Table 2). The workplace environment is implicated by the fact that these symptoms can be severe enough to result in missed work, reassignment, and even termination. This causes increased anxiety among the workers and, often times, makes the investigation of these problems even more difficult.

TABLE 2

Common Health Complaints

Eye Irritation  
Dry Throat  
Headache  
Fatigue  
Sinus Congestion  
Skin Irritation  
Shortness of Breath  
Cough  
Dizziness  
Nausea  
Sneezing  
Nose Irritation

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Although some of these episodes may be made up of several factors combined, we have classified the results found in our HHE Program by primary type of problem found: contamination from the building materials (4%); microbial contamination (5%); other contamination from inside the building (15%); contamination from outside the building (10%); inadequate ventilation (53%); and unknown (13%).

As mentioned above, in over half of our indoor air quality investigations, inadequate ventilation was found to be the cause of complaints. Heating, ventilating, and air conditioning (HVAC) conditions that can cause indoor air quality problems include migration of odors or chemical hazards between building areas, re-entrainment of building exhaust through heat recover devices or improper placement of exhaust and intake stacks, buildup of microorganisms in HVAC system components and poor odor and environmental control due to insufficient "fresh" outdoor air. The insufficient use of "fresh" outdoor air has been compounded by reduction in ventilation airflows because of energy conservation. The inadequacy of building ventilation can be evaluated by monitoring ambient carbon dioxide (CO<sub>2</sub>) concentrations, temperature, humidity, and airflow. However other chemical agents from sources other than human occupants also increase with adequate building ventilation.

In 20-25% of our indoor air quality surveys, sources inside the building have been identified as the major generators of indoor air pollution. To date, common sources that have been identified include: duplicators-methyl alcohol; signature machines - butyl methacrylate; blueprint copiers--ammonia; acetic acid; pesticides; boiler additives--diethyl ethanolamine; cleaning agents; tobacco smoke and combustion gases; foam insulation, particle board, plywood, construction glues and adhesives--formaldehyde, and organic solvents; lined ventilation ducts--fibrous glass; silicone caulking and curing agents. In these situations, we have found that low concentrations of agents need to be monitored since odor thresholds, comfort and unusual stimuli may be the significant factors rather than higher concentrations where health effects have been established. Also, in many instances no evaluation criteria exist and the investigators must compare areas where complaints are frequent with areas which have no complaints to search for chemical, biological, physical, and organizational factors which may be the cause. Given the problems with identifying emission sources and the need to measure at low levels, sensitive and specific direct-reading instruments need to be followed with highly specific, low level chemical analysis in the laboratory.

To complicate the investigations concerning poor air quality, ergonomics and psychosocial issues often are encountered. For example, our research teams, composed of behavioral scientists, physicians and industrial hygienists, have investigated a series of mass illness outbreaks in various work settings for which there was no apparent physical or chemical cause. The reported symptoms are typically vague and nonspecific, and frequently are described by workers as ill defined contaminants in the workplace (e.g., bad odors, stuffy or heavy air). Questionnaire surveys and interviews of both affected and unaffected workers suggest that the expression of the symptoms may have been exacerbated by a variety of ergonomic, organizational and psychosocial stresses which increase worker job and life-dissatisfaction.

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Aside from NIOSH experiences discussed above, there have been considerable activities by other governmental and nongovernmental groups worldwide of which I am sure you are aware. Some major examples of these are as follows;

1. The National Research Council's Assembly of Life Science published "Indoor Air Pollutants" in 1981. The report lists a number of chemicals implicated in indoor air pollutant problems without assessing their importance. The Assembly also recommended that monitoring protocols and special instruments be developed to assess indoor air pollutants; that complaints of malaise, headache, stuffiness, and eye and throat irritation be studied; that the lowering of work productivity due to indoor pollution and associated discomfort be investigated; and that the influences of building design on the concentration of pollutants in commercial facilities be conducted.
2. The Environmental Protection Agency (EPA) published "EPA Indoor Air Quality Implementation Plan" in 1987 which not only described EPA's research agenda at that time, but dealt with those indoor air quality issues that concerned other Federal agencies. The document included a bibliography of indoor air quality literature containing over 2,000 entries.
3. In 1988, the Health and Safety Executive of Great Britain issued a report "Sick Building Syndrome: A Review." This report summarizes their experiences with "sick building syndrome," and discusses symptoms, common features of "sick buildings" and possible causes. Their experiences mirror that information found by our HHE Program.
4. A 1988 EPA publication, "Indoor Air Quality in Public Buildings" reported that concentrations of volatile organic compounds in new buildings were found to be as much as 100 times higher than those found outdoors.
5. Volume II of the Environmental Protection Agency's Report to Congress prepared in 1988/89 under Title IV of the Superfund Amendments and Reauthorization Act of 1986 highlights an up-to-date summary of the "Assessment and Control of Indoor Air Pollution." This volume discusses such issues as (a) factors affecting indoor air quality; (b) sources of pollutants and health effects; and (c) economic impacts.

These examples support the point that indoor air quality problems associated with worker health are significant and require continued vigilance.

In regard to your questions pertaining specifically to the Indoor Air Quality Act (S.657), the Administration has not yet taken a position on the specific contents of the proposed legislation.

Thank you for the opportunity to submit this testimony to the record.

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## ENCLOSURE I

### THE NIOSH APPROACH TO CONDUCTING INDOOR AIR QUALITY INVESTIGATIONS IN OFFICE BUILDINGS

National Institute for Occupation Safety and Health

#### ABSTRACT

Since 1971, personnel from the National Institute for Occupation Safety and Health (NIOSH) have complete over 500 indoor air quality (IAQ) investigations in a variety of office building environments. Most of these investigations have been conducted since 1979, paralleling the energy conservation concerns of building owners and operators. These investigations have been conducted under the authority of the NIOSH Health Hazard Evaluation Program and have been in direct response to reported health complaints or illness. Therefore, these IAQ investigations are intended to establish the identity of a problem and to recommend solutions for its correction. Over time, we have developed a consistent methodology with a "solution-oriented" approach to conducting these IAQ investigations. To initiate the investigation, the NIOSH team gathers background information by telephone and then makes a site visit to interview the affected employees and establish symptom identity and prevalence. During this initial site visit, the investigators also attempt to identify sources of contaminants, evaluate comfort parameters, and assess ventilation system performance. A variety of applicable evaluation criteria may be used, including "rules-of thumb" gleaned from the current scientific literature and our own experiences. If specific problems cannot be identified through these initial means, follow-up visits are then used to pursue a continually narrowing range of possibilities. This "solution-oriented" approach has resulted in the best allocation of our resources and has allowed the most efficient use of in-field as well as analytical personnel. In the IAQ investigations completed to date, problems were found to result from building material contaminants in 4%, microbiological contaminants in 5%, contaminants brought in from outside the building in 10%, contaminants from inside the building in 15% and inadequate ventilation problems in 53%. The remaining 13% represent those investigations where no problem could be identified.

#### INTRODUCTION

The sometimes questionable quality of indoor air and the potential for health risks have become major concerns of building occupants, especially office workers. Some potential indoor exposures, such as to the carcinogen, asbestos, have well-documented health implications. But, more commonly, the health risks of other indoor air exposures are poorly understood. Nevertheless, office workers experiencing indoor air quality (IAQ) problems often demand a complete evaluation of their work environment and of the effect it may have upon their health.

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At the National Institute for Occupation Safety and Health (NIOSH), the majority of our indoor air quality investigations are conducted as part of the Health Hazard Evaluation Program. We conduct these health hazard evaluations at the request of employee groups, unions, management, and local, State and Federal agencies. Generally, these requests are in response to existing worker health complaints and illness. Because we are essentially "invited" to conduct these investigations, the data presented here will not reflect a statistically valid cross-section of the indoor air quality problem. However, these findings are drawn from one of the largest single information bases currently available on the subject. In essence, this paper will summarize the NIOSH methodology currently used during IAQ investigations and some of the data from these IAQ investigations completed since the start of the Health Hazard Evaluation Program.

#### METHODOLOGY

We have found that investigating IAQ problems can present a formidable challenge which, in some ways, is more difficult than evaluating industrial environments. In an industrial situation, the evaluation will be directed by investigations of the materials used by, or in the vicinity of, the affected workers. These materials can usually be chemically analyzed which permits techniques and potential health effects using standard medical and epidemiologic techniques. Frequently there are exposure criteria which can be applied to help interpret the data obtained. This is rarely the case with an indoor air quality problem.

Indoor air quality investigations tend to become more complicated as time passes without identification of a cause. Frustrations result in highly charged emotions which only further impede continued evaluation efforts. These situations are further complicated by the fact that symptoms are not easily attributed to a single cause and the application of standard industrial hygiene, medical and epidemiologic techniques may prove to be inconclusive.

Over time, our approach in evaluating this situation has changed. We have developed a more consistent, solution-oriented approach that systematically excludes a continually narrowing range of possibilities. Generally, this exclusion hierarchy, which has come about based on our past experiences, involves evaluation of physical, chemical and microbiological factors, in the order presented. Each of these potential causation categories are discussed in more detail later in this presentation.

Since we anticipate that IAQ requests will continue to represent a substantial percentage of the total health hazard evaluation requests (currently about 20%), three response levels have been developed. Based on the information obtained during initial telephone with the requestor, the following responses are possible:

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1. Provide "self-help evaluation" materials (attached). Remain available for consultation by telephone. Become more involved, if necessary.
2. NIOSH conducts an initial evaluation and provides recommendations to solve the problem or for further study on a "self-help" basis.
3. NIOSH conducts a full scale investigation.

The NIOSH investigation team commonly includes an industrial hygienist and physician/epidemiologist, but can also include other professionals such as an engineer. Most investigations contain the following parts: background assessment, initial site assessment, and, if necessary, additional site assessment.

#### BACKGROUND ASSESSMENT

For the background assessment, we initially obtain, by telephone, as much information on the building as practicable, an idea of symptoms being experienced, and a chronology of the problem. Much of this information can be collected using a standard questionnaire. We also request copies of other previous investigations which are relevant to the problem at hand. These data are then used to tailor the protocol for the initial site assessment so as to make it more efficient.

#### INITIAL SITE ASSESSMENT

For the initial site assessment, a common protocol includes five separate steps or parts: an opening conference, a walk-through evaluation, personal interviews, phase I of environmental monitoring, and a closing conference.

**Opening Conference--**The opening conference is attended by representatives of the employer and employees (where applicable) as well as someone who has knowledge of the operation, and maintenance of the building's heating, ventilating and air conditioning (HVAC) systems. This meeting serves to present NIOSH's role, discuss anticipated activities and arrange to receive copies of pertinent data not already received.

**Walk-through Survey--**The walk-through survey will involve all or part of the building including inspection of the HVAC systems with special attention given to the mechanism by which outside air enters each HVAC unit. Architectural plans and ventilation test and balance reports may also be reviewed during this phase. Potential sources of emission are identified so that each may be further evaluated, as needed.

**Personal Interview--**Personal interviews are often conducted to determine the extent, prevalence and character of reported symptoms. The use of a questionnaire, such as the one shown in Appendix 1, may be the most efficient means of collecting this type of information. It can be used as a guide during personal interviews or it can be self-administered

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Phase I Environmental Monitoring--Phase I environmental monitoring is usually conducted on each initial survey. The scope of this effort may vary, but usually will either evaluate certain aspects of the building environment, which we have come to believe are important factors in all investigations, or explore any other possibilities made apparent from the background assessment. Evaluation of the ventilation system using both actual measurement and/or carbon dioxide (CO<sub>2</sub>) techniques, and monitoring temperature and relative humidity are useful procedures for all evaluations during the initial site assessment. Monitoring for formaldehyde is an example of a specific method which may be used if the background assessment indicates that respiratory system and eye irritation are prevalent complaints and the space has been recently built or renovated (a number of furnishings are potential sources of formaldehyde). Most of the monitoring accomplished on the initial survey is obtained using direct-reading instruments where possible because they provide results on-the-spot. Any deficiencies noted can be corrected and re-evaluated. Trace concentrations of hundreds of compounds could be identified depending on the extent of the sampling and analytical effort; however, the concentrations usually detected would not be expected to cause adverse health effects in a normal healthy individual. Other techniques which I will now discuss have been consistently more useful.

Evaluating HVAC Systems--HVAC systems can be complicated and most industrial hygienists have received very little or no training in the design, maintenance and trouble-shooting of building ventilation systems. The most important aspect of evaluating HVAC systems is to gain an understanding of how they are supposed to be working and then use some relatively simple methods to convince yourself that the system is performing up to the design specifications, and whether this is adequate with respect to the complaint areas in the building, return to the complaint area(s) and measure supply and return air flows using either a velometer or a flow hood and compare the results to the design quantities. Note that in variable-air-volume (VAV) systems the supply air flows may vary during the day.

A method which is gaining popularity, and which is currently used by NIOSH for evaluating the adequacy of ventilation to an area is the measurement of CO<sub>2</sub> concentrations. Humans expire significant quantities of CO<sub>2</sub>. The higher the CO<sub>2</sub> levels inside a building, the poorer the overall ventilation, in a general sense. We believe that complaints will not be prevalent if interior CO<sub>2</sub> concentrations are maintained at twice or less the outdoor levels (usually 250-300 ppm). At CO<sub>2</sub> concentrations above 1000 ppm, or 3 to 4 times the outdoor level, complaints of headaches tiredness, eye, nose and throat irritation may be more prevalent. It is important to realize that it is not the CO<sub>2</sub> concentration that is causing the symptoms; but, if CO<sub>2</sub> increase, so may all the other normal airborne contaminants and it may be some combination of all these substances that make people uncomfortable. Carbon dioxide measurement can be obtained using standard detector tubes or portable CO<sub>2</sub> monitoring instruments. The use of CO<sub>2</sub> as an index of the general quality of indoor air is currently being evaluated by NIOSH as well as many other agencies.

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Poor mixing of air is another potential problem sometimes found when air is delivered and returned through ceiling diffusers. Standard smoke tubes, and temperature and CO<sub>2</sub> measurements at 1 foot and 7 foot heights above the floor may be useful techniques in evaluating stratification resulting from poor mixing.

Monitoring Temperature and Relative Humidity--Temperature too cold, too warm or fluctuating can be a source of complaints. While individuals vary in their limits of thermal comfortability, if a significant number of workers in an area complain (more than 20%), then temperature and relative humidity may be creating an uncomfortable environment. If temperatures are too warm, complaints of tiredness, lack of concentration and headache may also be reported. Low relative humidities, not uncommon in the winter in a building or residence that is not humidified, can cause eye, nose and throat irritation.

#### CLOSING CONFERENCE

The closing conference of the initial site survey provides an opportunity to present the NIOSH activities accomplished, any results obtained and recommendations on corrective actions if potential problems were identified. If no problems were identified, recommendations may be made on how to continue studying the problem either on a self-help basis or through continued NIOSH involvement. Typical recommendations when we have not identified a probable explanation for the reported symptoms would include the formulation of a more formalized method of reporting worker symptoms on a daily basis and the generation of HVAC data logs to provide evidence that the HVAC system is performing in a consistent manner over time.

#### EVALUATION CRITERIA

Evaluation criteria used to interpret environmental measurements vary. In the classic industrial hygiene sense, the Occupational Safety and Health Administration's (OSHA) permissible limits [1], the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values [2], and NIOSH's recommended exposure limits [3] are most commonly used in occupational exposure assessments. Because these criteria are based on health effects as they pertain to the manufacturing environment, they may not have the same relevance for workers in an office setting, whose primary concern may be for comfort or simply an absence of unusual sensory stimuli over their working period. The Environmental Protection Agency (EPA) has ambient air quality standards [4] for a variety of pollutants designed to protect the public over an entire day (not just an 8-hour workday). However, these, too, may not have relevance to an indoor office environment, especially from the perspective of problem-solving.

The American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE) guidelines for acceptable indoor air quality [5] have been developed for the indoor environment. We commonly use these as criteria in our office building evaluations, especially for assessing the performance of a ventilation system. We also use the ASHRAE comfort guidelines [6] as criteria for assessing the thermal performance of occupied space.

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## ADDITIONAL SITE ASSESSMENTS

If the background assessment and the initial site visit identify a problem that need further definition, or if no problem can be isolated, an additional site assessment may be performed. During the additional site assessment, more specific and extensive monitoring may be conducted for chemical and/or microbiological contaminants of interest. Sampling for airborne microbiological contaminants is also outside of what is considered a standard industrial hygiene technique. Useful techniques are still under evaluation. Methodology is available; however, analytical support is somewhat limited. Nevertheless, the topic of potential microbiological contamination usually comes up as an investigation progresses. Close visual inspection of the various HVAC components will usually uncover a microbiological problem if present.

The condition most commonly associated with exposure to airborne organisms is hypersensitivity pneumonitis. This is a general term for a disease which occurs as a result of an immunologic inflammatory reaction to the inhalation of any of a variety of organic dusts. Terms like humidifier fever, ventilation pneumonitis, farmer's lung and cheese worker's lung are all the result of these exposures. Symptoms are usually described as a recurring "flu-like" syndrome. Diagnosis is based on a combination of characteristic symptoms, chest x-rays, pulmonary function abnormalities and sometimes immunologic studies [7].

Inspection of the HVAC system and confirmation of the diagnoses of hypersensitivity pneumonitis among workers may be more useful than air sampling for airborne microorganisms until investigative techniques are further refined.

## DISCUSSION

Through December 1988, 529 NIOSH indoor air quality health hazard evaluations have been completed (Table 1). These do not include our investigations of asbestos-in-building problems, but only those where the building occupants were actually experiencing ill health effects. The number of investigations has increased markedly since 1979. This is most probably due to a couple of factors: increased energy conservation measures and increased worker awareness of their office environment. We now average about two indoor air quality investigations per week.

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TABLE 1

NIOSH INDOOR AIR QUALITY INVESTIGATIONS  
BY YEAR (THROUGH DECEMBER 1988)

| Year     | Number<br>Completed | %        |
|----------|---------------------|----------|
| Pre-1978 | 6                   | 1        |
| 1978     | 9                   | 2        |
| 1979     | 12                  | 3        |
| 1980     | 28                  | 6        |
| 1981     | 82                  | 18       |
| 1982     | 52                  | 12       |
| 1983     | 61                  | 14       |
| 1984     | 56                  | 13       |
| 1985     | 81                  | 18       |
| 1986     | 59                  | 13       |
| 1987     | 38                  | 8        |
| 1988     | <u>45</u>           | <u>9</u> |
| Total:   | 529                 | 100      |

While the majority of our investigations have been conducted in government and private-sector office buildings (Table 2), we have also looked at problems in schools, colleges, and health care facilities.

TABLE 2

NIOSH INDOOR AIR QUALITY INVESTIGATIONS  
BY BUILDING TYPE (THROUGH DECEMBER 1988)

| Building Type                      | # Completed | %        |
|------------------------------------|-------------|----------|
| Government and<br>Business Offices | 426         | 80       |
| Schools and Colleges               | 68          | 13       |
| Health Care Facilities             | <u>35</u>   | <u>7</u> |
| Total:                             | 529         | 100      |

Commonly, the symptoms and health complaints reported by the office workers are diverse and not specific enough to readily identify the causative agent (Table 3). The workplace environment is implicated by the fact that these symptoms normally disappear on weekends away from the office. At times, these symptoms can be severe enough to result in missed work, reassignment, and even termination. This causes increased anxiety among the workers and, often times, makes the investigation of these problems even more difficult and frustrating.

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TABLE 3

## COMMON HEALTH COMPLAINTS

|                  |                     |
|------------------|---------------------|
| Eye Irritation   | Shortness of Breath |
| Dry Throat       | Cough               |
| Headache         | Dizziness           |
| Fatigue          | Nausea              |
| Sinus Congestion | Sneezing            |
| Skin Irritation  | Nose Irritation     |

Although many of these problems may be multifactorial, we have classified our evaluations by primary type of problem found: contamination from the building material (4%); microbiological contamination (5%); contamination from outside the building (10%); contamination from inside the building (15%); inadequate ventilation (53%); and unknown (13%) (Table 4.) There are some shortcomings to these data, however, in that they may not represent a "true" cross-section of the indoor air quality problem as previously discussed. For example, we have not used a standard protocol for all these evaluations, as our methods and criteria have evolved with time and experience. Also, since many of these investigations were reviewed retrospectively, there may be some misclassification due to the vagueness of earlier reports. Lastly, we have little follow-up data on many of these evaluations to enable us to determine the efficacy of our recommendations[8].

TABLE 4

NIOSH INDOOR AIR QUALITY INVESTIGATIONS  
BY PROBLEM TYPE (THROUGH DECEMBER 1988)

| Problem Type                     | # Completed | %   |
|----------------------------------|-------------|-----|
| Building Materials Contamination | 21          | 4   |
| Microbiological Contamination    | 27          | 5   |
| Outside Contamination            | 53          | 10  |
| Inside Contamination             | 80          | 15  |
| Ventilation Inadequate           | 280         | 53  |
| Unknown                          | 68          | 13  |
| Total:                           | 529         | 100 |

## BUILDING MATERIALS CONTAMINATION

Contamination from building materials and products was the major problem in 4% of our investigations. Formaldehyde can off-gas from urea-formaldehyde foam insulation, particle board, plywood, and some glues and adhesives commonly used during construction. Other building fabric contamination problems encountered included dermatitis resulting from fibrous glass, various organic solvents from glues and adhesives, and acetic acid used as a curing agent in silicone caulking.

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## MICROBIOLOGICAL CONTAMINATION

Five percent of our investigations have involved some type of microbiological contamination. Even though this is not a common cause of office problems, it can result in a potentially severe condition known as hypersensitivity pneumonitis. This respiratory problem can be caused by bacteria, fungi, protozoa, and microbial products that may originate from ventilation system components. A similar condition known as humidifier fever, most commonly reported in Europe, is also a result of microbiological contamination in ventilation systems. In our investigations, microbiological contamination has commonly resulted from water damage to carpets or furnishings, or standing water in ventilation system components.

## OUTSIDE CONTAMINATION

Contamination from sources outside the office space was the major problem identified in 10% of our investigations. Problems due to motor vehicle exhaust, boiler gases, and previously exhausted air are essentially caused by re-entrainment. This is usually the result of improperly locked exhaust and intake vents or periodic changes in wind conditions. Other outside contamination problems include contaminants from construction or renovation such as asphalt, solvents, and dusts. Also, gasoline fumes infiltrating the basement and/or sewage system can sometimes be a problem and are usually caused by gasoline leaks from ruptured underground tanks at nearby service stations. One of the most common sources of outside contamination has been carbon monoxide fumes from basement parking garages being recirculated through the building ventilation system.

## INSIDE CONTAMINATION

Contamination generated by sources inside the office space was the major problem identified in 15% of our investigations. Copying machines are often found to be a significant source. Examples of this type of problem would include methyl alcohol from spirit duplicators, butyl methacrylate from signature machine and ammonia and acetic acid from blueprint copiers. Still other inside contamination problems we have encountered include pesticides which were improperly applied; dermatitis from boiler additives such as diethyl ethanolamine; improperly diluted cleaning agents such as rug shampoo; tobacco smoke of all types; combustion gases from sources common to cafeterias and laboratories; and cross-contamination from poorly ventilated sources that leak into other air handling zones.

Contaminants from inside or outside the office space, and from the building fabric are essentially chemical contaminants. Many times odors are associated with some of these contaminants which may aid in source identification. Additionally, in most cases, these chemical contaminants were measured at levels above ambient but far below any existing occupational standard.

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## INADEQUATE VENTILATION

In 53% of our investigations, the building ventilation has been inadequate. When evaluating building ventilation, we normally use ASHRAE standards for comparison. ASHRAE standards 62-1981, "Ventilation for Acceptable Indoor Air Quality" (ASHRAE 1981) and 55-1981, "Thermal Environmental Conditions for Human Occupancy" (ASHRAE 1981) are both used. Some of the ventilation problems we commonly encounter are: not enough outdoor air supplied to the office space; poor air distribution and mixing which causes stratification, draftiness, and pressure differences between office spaces; temperature and humidity extremes of fluctuations (sometimes caused by poor air distribution); and air filtration problems caused by improper or no maintenance to the building ventilation system. In many cases, these ventilation problems are created or enhanced by certain energy conservation measures. These include reducing or eliminating outdoor air; reducing infiltration and exfiltration; lowering thermostats in winter, raising them in summer; eliminating humidification or dehumidification systems; and early shut-down and late start-up of ventilation systems.

## CONCLUSION

The major problems identified in these NIOSH indoor air quality investigations can be placed into three general categories listed with decreasing frequency: inadequate ventilation, chemical contamination, and microbiological contamination. Inadequate ventilation is the single largest problem we have seen in buildings. Although varied, these ventilation problems commonly can allow a build-up of any contaminants present in the occupied space to the point that adverse health effects are experienced or allow the environment to become annoyingly uncomfortable to the office workers. As our experience increased over time, we developed a solution-oriented approach to conducting these evaluations which places a high priority on building ventilation. This approach has resulted in the best allocation of our resources and has allowed more efficient use of in-field as well as analytical time.

Increasing office worker awareness and the current shift to office-based, service-type employment will no doubt increase concerns about the indoor air quality in offices and other non-industrial settings. More research into office building ventilation and its effect on background levels of contaminants will be necessary to provide additional and more appropriate guidelines for the evaluation and control of indoor air quality problems in the future.

Early recognition of a problem, with a timely and systematic evaluation, are key factors to a quick and effective resolution.

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## REFERENCES

- [1] OSHA, OSHA Safety and Health Standards, Occupational Safety and Health Administration, Washington, D.C., 1983.
- [2] ACGIH, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment and Biological Exposure Indices with Intended Changes for 1985-1986, Cincinnati: American Conference of Governmental Industrial Hygienists, 1985.
- [3] CDC, "NIOSH Recommendations for Occupational Safety and Health Standards," Morbidity and Mortality Weekly Report, Vol. 35, 1985, pp. 35-315.
- [4] EPA, National Primary and Secondary Ambient Air Quality Standards, Washington, D.C.: Environmental Protection Agency, 1971.
- [5] ASHRAE, ASHRAE Standard 62-1981, "Ventilation for Acceptable Indoor Air Quality," Atlanta: American Society for Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1981.
- [6] ASHRAE, ANSI/ASHRAE Standard 55-1981, "Thermal Environmental Conditions for Human Occupancy," Atlanta: American Society for Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1981.
- [7] Levy, M.B. and Fink, J.N., "Hypersensitivity Pneumonitis," Annals of Allergy, Vol. 54, 1985, pp. 167-171.
- [8] Melius, J., Wallingford, K., Keenlyside, r., Carpenter, J., "Indoor Air Quality--the NIOSH Experience," Annals of the American Conference of Governmental Industrial Hygienists, Vol. 10, 1984, pp 3-7.

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